
6. Appendix

6.1 Stopping range of 30 keV Ga⁺-ions

A knowledge of the stopping range, is necessary, in order to estimate the volume fraction of the sample material, which is affected by the ion beam.

For the estimation of the stopping range of 30 keV Ga⁺-ions, a Monte-Carlo simulation was used. Ziegler and Biersack (2004) developed the Monte-Carlo simulation TRIM, which allows the calculation of the stopping range of ions in solids. For a simulation of the stopping range, several parameters of the sample material are required such as the elements of the sample material, the binding energies, the binding conditions. For biological materials, these parameters are not completely known, so the reference material polyimide (Kapton[®]) was chosen, which has known and uniform material properties and a microstructure comparable to biological materials.

The current version of TRIM in SRIM 2003.26 was used to calculate the stopping range of 1000 ions which are accelerated with an energy of 30 keV towards a 125 μm thick polyimide (Kapton[®]) foil. The material parameters for Kapton[®] were found in the material library of the program TRIM. Figure 6.1 shows the frequency distribution of the stopping range of the Ga⁺-ions. The minimum, mean and maximum stopping range of 30 keV Ga⁺-ion in a 125 μm thick polyimide foil are 13.6 nm, 36 nm and 73 nm, respectively. The minimum, mean and maximum radial distances from the incident position (x: 0, y: 0) of the stopped 30 keV Ga⁺-ions are 0.2 nm, 8.6 nm and 30 nm respectively. Figure 6.2 shows the volume distribution and Figure 6.3 shows the lateral distribution for 1000 ions in polyimide.

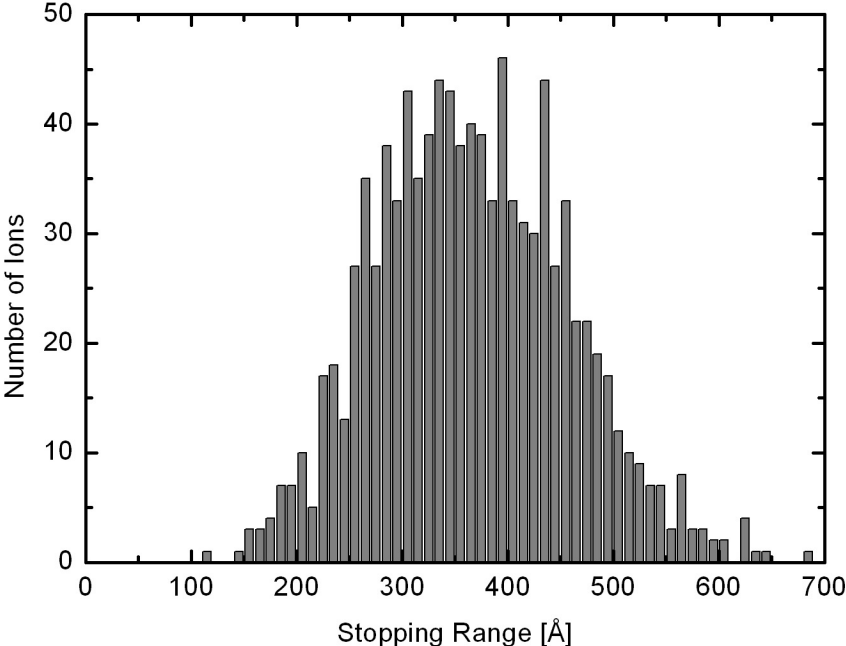


Figure 6.1: Frequency distribution of the Monte-Carlo Simulation TRIM of the stopping range of 1000 30 keV Ga⁺ ions in a 125 μm thick polyimide foil (Kapton[®]).

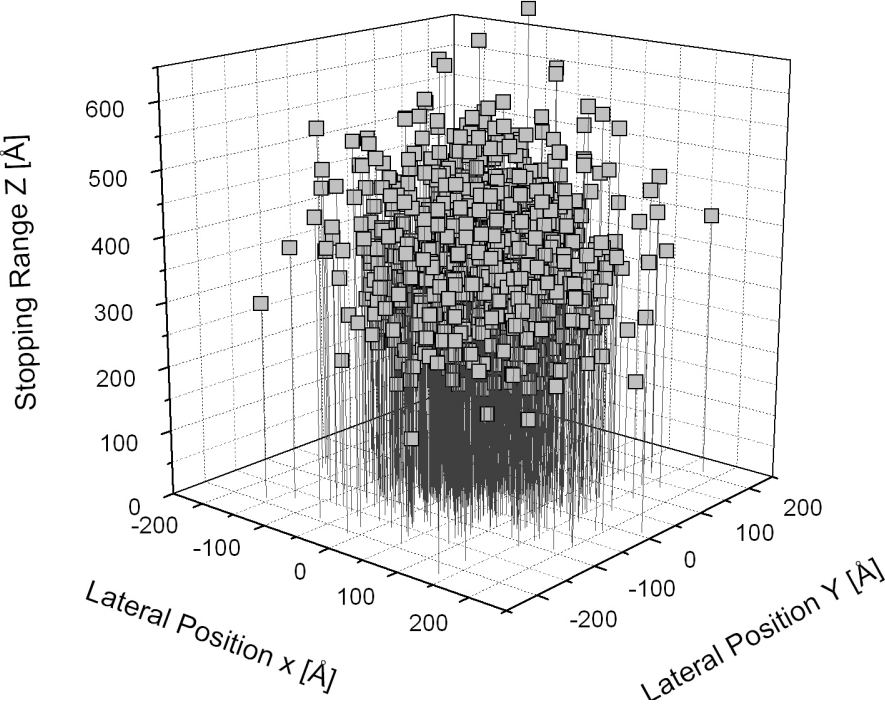


Figure 6.2: TRIM calculated volume distribution of 1000 ions in polyimide.

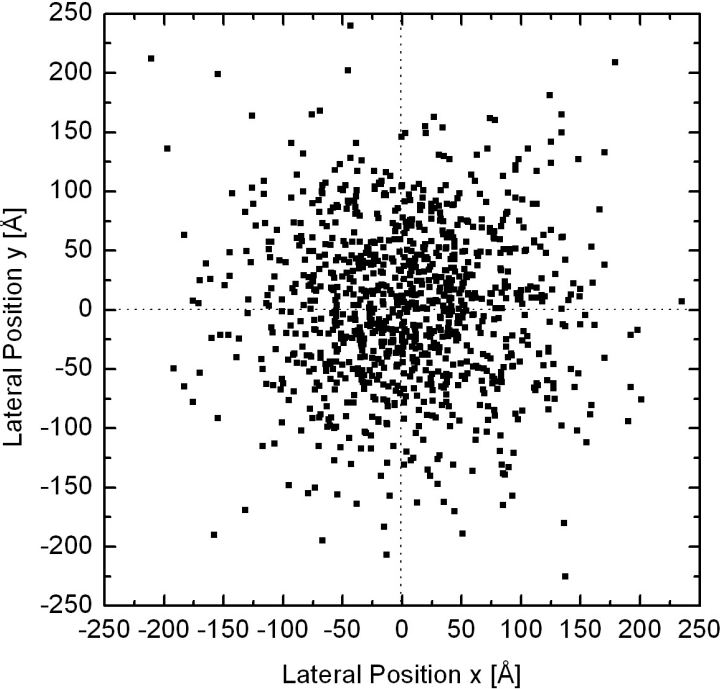
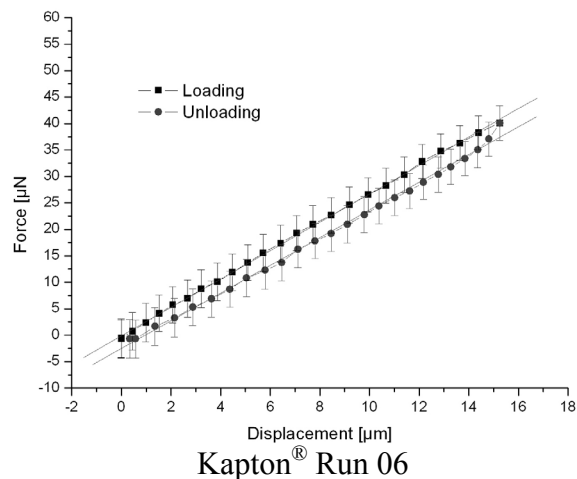
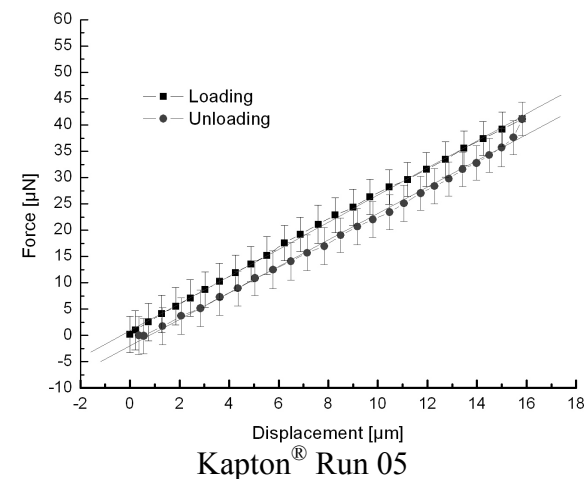
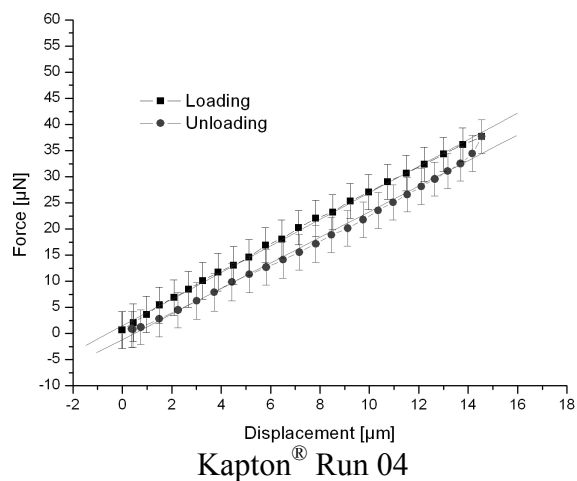
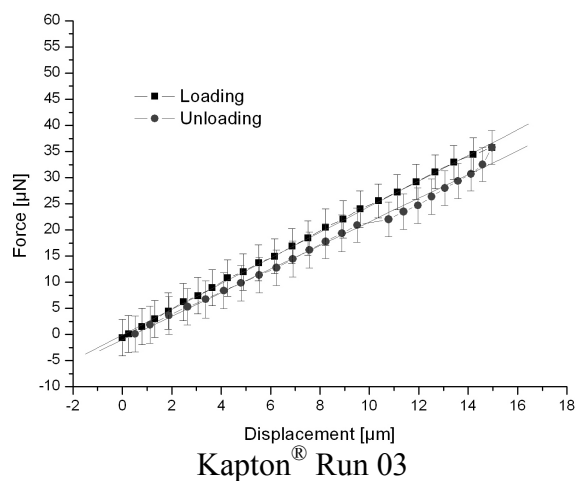
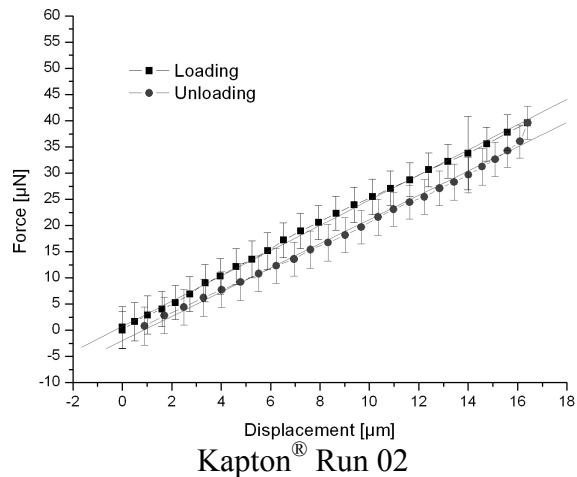
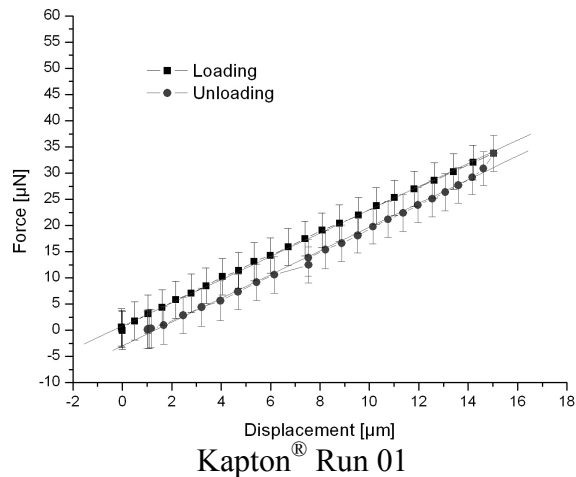


Figure 6.3: Lateral distribution of 1000 ions accelerated onto a Kapton[®] foil, hitting the surface at the position x: 0, y: 0.

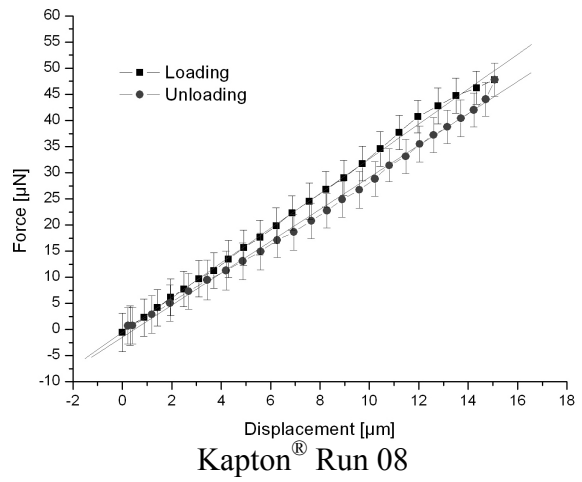
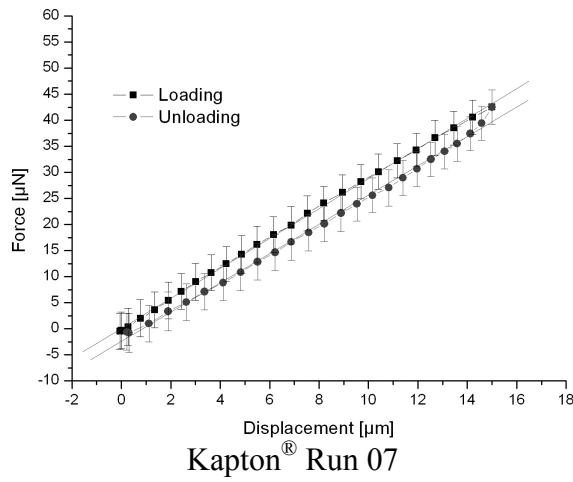
6.2 Load-deflection curves of the beam bending experiments

6.2.1 Kapton[®]

Load deflection curves of a 248.3 μm long, 15.4 μm wide and 13.1 μm thick Kapton[®] cantilever, tested at several positions along the samples length are shown. The cantilever was micromachined from a Kapton[®] sheet using the FIB. The loading curve has rectangular symbols, the unloading curve circular onse.



6. Appendix



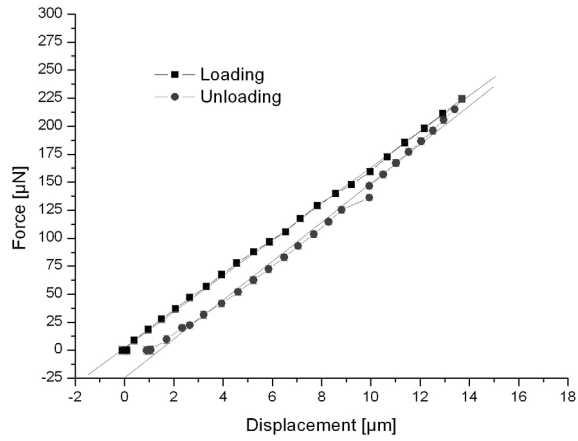
From the slopes of the loading and unloading curves, the Young's modulus was calculated using Equation [2.4].

Table 6.1: Young's modulus calculated from the loading and unloading curve at different positions along the Kapton[®] cantilever.

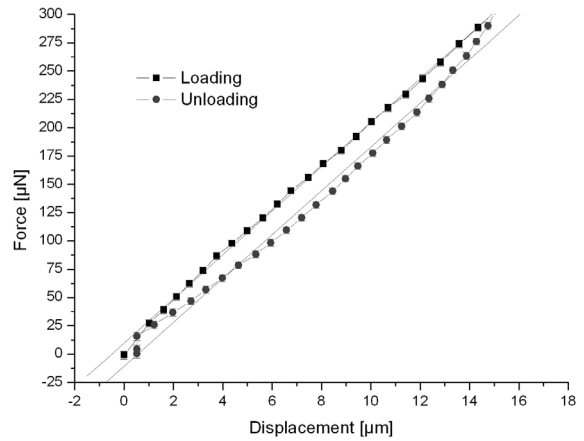
Run	Cantilever length [µm]	Estimated cantilever stiffness [N/m]	Young's modulus loading [GPa]	Young's modulus unloading [GPa]
01	240.04	2.26	3.54±0.69	3.62±0.51
02	238.15	2.31	3.76±0.59	3.61±0.50
03	236.89	2.26	3.77±0.65	3.47±0.56
04	235.03	2.45	3.82±0.68	3.67±0.59
05	233.18	2.51	3.77±0.63	3.68±0.58
06	227.92	2.62	3.67±0.60	3.58±0.59
07	223.07	2.81	3.69±0.59	3.60±0.52
08	215.63	3.06	3.85±0.38	3.54±0.50

6.2.2 Hair from a horse tail

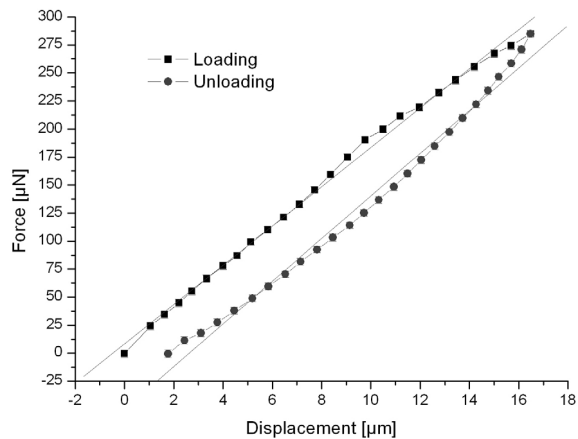
Load deflection curves of a hair from a horse tail with a diameter of $156\ \mu\text{m}$ and a length of $3167\ \mu\text{m}$ tested in bending at several positions along the sample length are shown. The loading curve has rectangular symbols, the unloading curve circular ones.



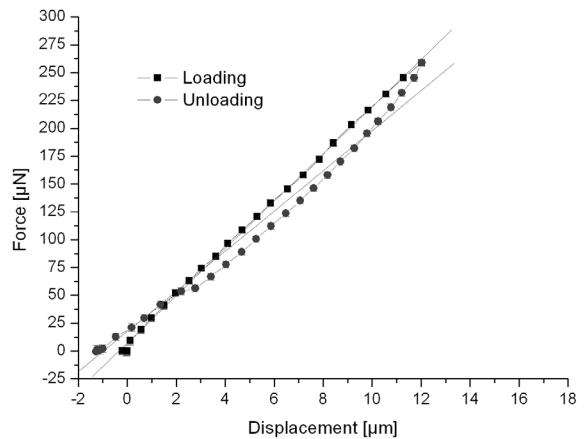
Horse hair Run 01



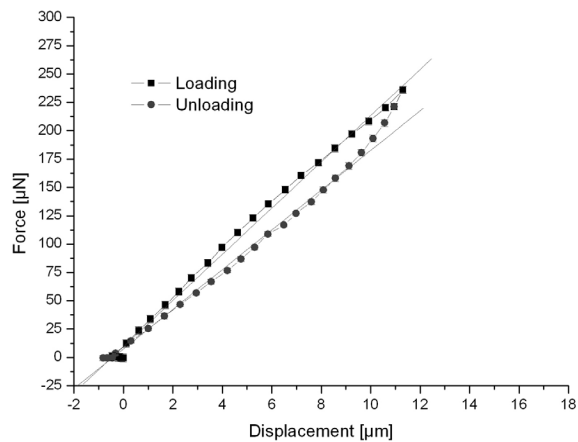
Horse hair Run 02



Horse hair Run 03



Horse hair Run 04



Horse hair Run 05

6. Appendix

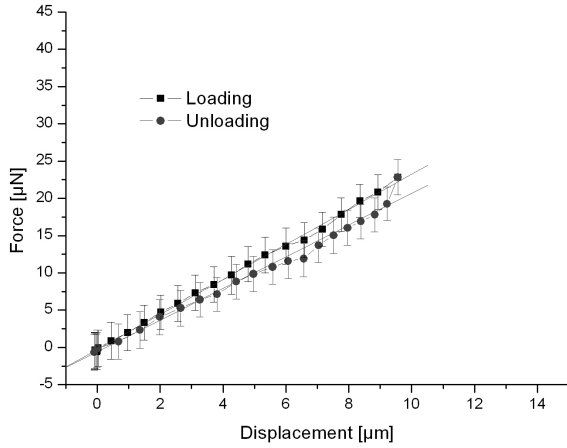
From the slope of the loading and unloading curve, the Young's modulus was calculated using Equation [2.5].

Table 6.2: Young's modulus of a horse hair (keratin), calculated from the loading and unloading curve at different beam length.

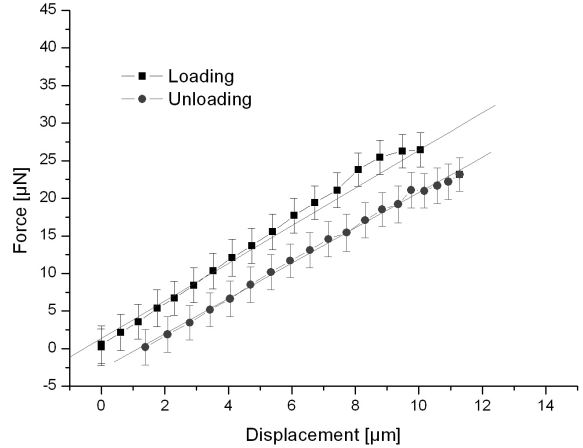
Run	Cantilever length [μm]	Estimated samples stiffness [N/m]	Young's modulus loading [GPa]	Young's modulus unloading [GPa]
01	3116.0	16.11	5.59 \pm 0.58	6.33 \pm 0.56
02	3087.0	17.54	5.91 \pm 0.72	6.93 \pm 0.68
03	3054.0	19.47	6.36 \pm 0.69	6.32 \pm 0.67
04	3048.7	21.21	6.89 \pm 0.65	6.57 \pm 0.72
05	3049.3	20.38	6.62 \pm 0.70	5.70 \pm 0.60

6.2.3 Spruce wood cell wall material

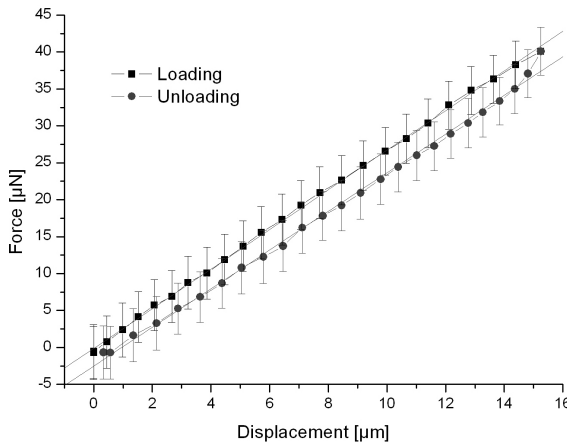
Load deflection curves of a 353.0 μm long, 17.39 μm wide and 3.47 μm thick cantilever of wood cell wall material, cut from a spruce wood tracheid, are shown. The sample was tested at several positions along the cantilever. The loading curve has rectangular symbols, the unloading curve circular ones.



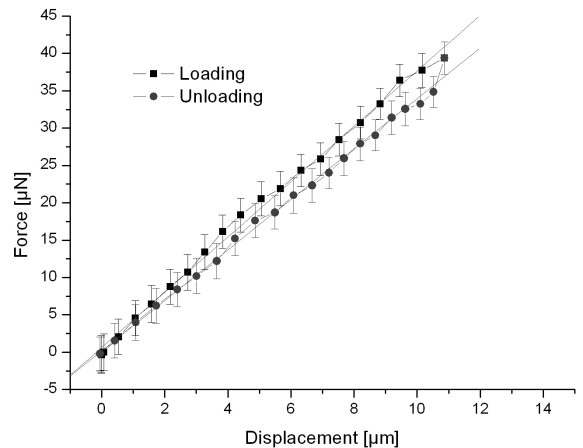
Spruce wood Run 01



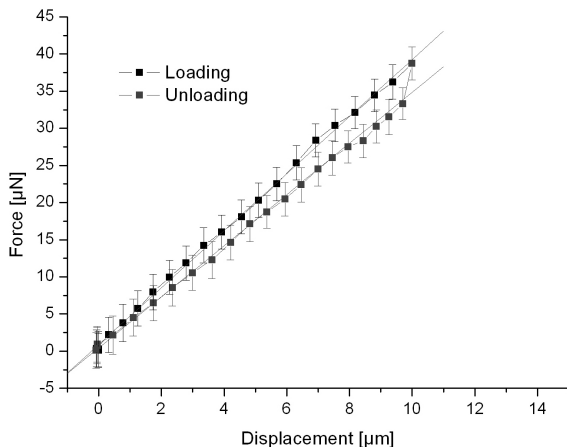
Spruce wood Run 02



Spruce wood Run 03



Spruce wood Run 04



Spruce wood Run 05

6. Appendix

From the slope of the loading and unloading curves, the Young's modulus was calculated using Equation [2.5].

Table 6.3: Young's modulus calculated from the loading and unloading curve at different positions along the wood cell wall material cantilever.

Run	Cantilever length [μm]	Estimated samples stiffness [N/m]	Young's modulus loading [GPa]	Young's modulus unloading [GPa]
01	134.1	1.88	31.3 \pm 5.83	28.3 \pm 5.91
02	122.8	2.44	25.6 \pm 3.09	24.0 \pm 3.96
03	114.0	3.05	30.5 \pm 4.39	26.7 \pm 4.03
04	109.8	3.42	27.1 \pm 3.25	24.7 \pm 2.72
05	108.1	3.58	26.2 \pm 3.23	24.0 \pm 3.44

6.3 Error calculations

6.3.1 Beam bending

Error bars in the force deflection curves

The error bars in the Force deflection curves of the beam bending experiments are the standard deviation of the force and the error in deflection taken as the length corresponding to two pixel in the micrographs taken during the experiments. The error bar of the deflections is equal (or smaller) to the size of the symbols in the plots.

Error in the calculation of the Young's modulus

The error in the calculation of the Young's modulus from the beam bending experiments is the standard deviation calculated from an error propagation of the Equations [2.4] and [2.5] in Chapter 2.6. The standard deviation for the Young's modulus of a rectangular cantilever ΔE_{rect} using an error propagation of Equation [2.4] is given by:

$$\Delta E_{rect} = \sqrt{\left(\frac{\partial E}{\partial \frac{F}{\delta}}\right)^2 \cdot \left(\Delta \frac{F}{\delta}\right)^2 + \left(\frac{\partial E}{\partial l}\right)^2 \cdot (\Delta l)^2 + \left(\frac{\partial E}{\partial w}\right)^2 \cdot (\Delta w)^2 + \left(\frac{\partial E}{\partial h}\right)^2 \cdot (\Delta h)^2} \quad [6.1]$$

$$\frac{\partial E}{\partial \frac{F}{\delta}} = 4 \cdot \frac{l^3}{w \cdot h^3} \quad [6.2]$$

$$\frac{\partial E}{\partial l} = 12 \cdot \frac{F}{\delta} \cdot \frac{l^2}{w \cdot h^3} \quad [6.3]$$

$$\frac{\partial E}{\partial w} = -4 \cdot \frac{F}{\delta} \cdot \frac{l^3}{w^2 \cdot h^3} \quad [6.4]$$

$$\frac{\partial E}{\partial h} = -12 \cdot \frac{F}{\delta} \cdot \frac{l^3}{w \cdot h^4} \quad [6.5]$$

The standard deviation for the Young's modulus of a cylindrical cantilever using an error propagation of Equation [2.5] is given by:

$$\Delta E_{cyl} = \sqrt{\left(\frac{\partial E}{\partial \frac{F}{\delta}}\right)^2 \cdot \left(\Delta \frac{F}{\delta}\right)^2 + \left(\frac{\partial E}{\partial l}\right)^2 \cdot (\Delta l)^2 + \left(\frac{\partial E}{\partial r}\right)^2 \cdot (\Delta r)^2} \quad [6.6]$$

$$\frac{\partial E}{\partial \frac{F}{\delta}} = \frac{4}{3} \cdot \frac{l^3}{\pi \cdot r^4} \quad [6.7]$$

$$\frac{\partial E}{\partial l} = 4 \cdot \frac{l^2}{\pi \cdot r^4} \quad [6.8]$$

$$\frac{\partial E}{\partial r} = -\frac{16}{3} \cdot \frac{l^3}{\pi \cdot r^5} \quad [6.9]$$

$\Delta F/\delta$ is the error (standard deviation) of the slope, Δl of the length, Δw of the width, Δh of the height, and Δr of the radius.

The error in the slope F/δ of the force deflection curves was derived by graphical analysis. Two straight lines were fitted to the slope (taking the error bars of the force and deflection into account) of the force deflection curves. Both went through the so called focal point of the curves. The coordinates ($x_{\text{deflection}}/y_{\text{force}}$) of the focal point were calculated using Equations [6.10] (x coordinate) and [6.11] (y coordinate)

$$X = \frac{1}{N} \sum_{i=1}^N x_i \quad [6.10]$$

$$Y = \frac{1}{N} \sum_{j=1}^N y_j \quad [6.11]$$

N is the Number of values, x_i the values of the deflection, and y_j the values of the force, i and j are variables running from 1 to N . After fitting, the slopes (F/δ) of the two linear fits were measured and the standard deviation of the slope F/δ was calculated using Equation [6.12].

$$\Delta \frac{F}{\delta} = \pm \left| \frac{\left(\frac{F}{\delta} \right)_1 - \left(\frac{F}{\delta} \right)_2}{2} \right| \quad [6.12]$$

The length, width, height and diameter of the samples was measured in the SEM. The error in their measurement (Δl , Δw , Δh , and Δr) was estimated to be 2 % of the value, measured.

6.3.2 Tensile testing

The error in the force measurement ΔF was estimated to be 20 μN at most. The error in the strain $\Delta \varepsilon$ measurement was calculated using Equation [6.13]:

$$\Delta \varepsilon = \frac{\frac{1}{2} \text{ pixel}}{\text{sample length [pixel]}} \quad [6.13]$$

The smallest possible error $\Delta\varepsilon$ in the strain measurement (the highest strain resolution) can be achieved, when the sample is in the diagonal of the micrograph from which the strain can be measured. The maximum sample length in pixel which can be achieved using a resolution of 1024×881 pixels is 1350 pixel, and using Equation [6.13] the smallest error $\Delta\varepsilon_i$ in the strain measurements (the highest strain resolution) is 0.04 %. Typical strain errors are 0.05 to 0.06 %.

The standard deviation of the stress value $\Delta\sigma$ can be calculated from an error propagation using Equation [6.14]:

$$\Delta\sigma = \sqrt{\left(\frac{1}{A}\right)^2 \cdot (\Delta F)^2 + \left(-\frac{F}{A^2}\right)^2 \cdot (\Delta A)^2} \quad [6.14]$$

where A is the cross-sectional area, ΔA the error in the measurement of the cross-sectional area, ΔF the error in the force measurement and F the applied force.

The cross-sectional area A was calculated as described in Chapter 2.5. The area was calculated twice for every cross-section. The maximum deviation from the mean value of all cross-sectional areas was taken to be the error of the cross-sectional area ΔA .

The error of the Young's modulus was achieved by graphical analysis. In every stress-strain plot, two straight lines were plotted through the focal point of the plot (calculated as in Chapter 6.3.1 on beam bending), using Equations [6.10] and [6.11] and taking the error-bars into account. The slopes of the two lines were measured and their standard deviation and with it the standard deviation of the Young's modulus was calculated using Equation [6.15]:

$$\Delta \frac{\sigma}{\varepsilon} = \pm \left| \frac{\left(\frac{\sigma}{\varepsilon}\right)_1 - \left(\frac{\sigma}{\varepsilon}\right)_2}{2} \right|. \quad [6.15]$$

6.4 AutoIt Macros

All AutoIt macros used for the beam bending and tensile tests, which are described above, are listed in the following.

i) Beam bending

Leo Master

```
$antwort=0
$forward=0
$backward=0
$gorem=0
$gokd=0

FileDelete("E:\Bilder\Steffen\Test\prog\gorem.txt")
FileDelete("E:\Bilder\Steffen\Test\prog\goforward.txt")
FileDelete("E:\Bilder\Steffen\Test\prog\gobackward.txt")
FileDelete("E:\Bilder\Steffen\Test\prog\endbild.txt")

$forward = InputBox("Question", "Wieviele Schritte in positive A-Richtung?", "1")

$backward = InputBox("Question", "Wieviele Schritte in negative A-Richtung?", $forward)

While $forward >=1

    SplashTextOn("Master", "Belastung läuft !! Nummer " & $forward, 150, 100, 500, 500, "")

    Run("Bildspeichern.exe", "e:\Bilder\Steffen\Test\Start")

    While FileExists("E:\Bilder\Steffen\Test\prog\gorem.txt")=0
        sleep(600)
    WEnd

    sleep(800)

$gorem=0

;startet kleindiek

FileCopy("E:\Bilder\Steffen\Test\Start\goforward.txt", "E:\Bilder\Steffen\Test\prog")

    While FileExists("\Arpc89\KONTROLLE\start.txt")=0
        sleep(600)
    WEnd

    FileDelete("E:\Bilder\Steffen\Test\prog\goforward.txt")

    While FileExists("E:\Bilder\Steffen\Test\prog\goforward.txt")=1
        sleep(600)
    WEnd

sleep(600)

    While FileExists("\Arpc89\KONTROLLE\go.txt")=0
        sleep(600)
    WEnd

    sleep(600)

$forward=$forward-1

FileDelete("E:\Bilder\Steffen\Test\prog\gorem.txt")
FileDelete("E:\Bilder\Steffen\Test\prog\goforward.txt")
```

6. Appendix

```
FileMove("E:\Bilder\Steffen\Test\Master*.tif" , "E:\Bilder\Steffen\Test\Auswertung")

sleep(400)

SplashOff()

WEnd

While $backward >=1

    SplashTextOn("Master", "Entlastung Lauft !! Nummer " & $backward, 150, 100, 500, 500, "")

    Run("Bildspeichern.exe", "E:\Bilder\Steffen\Test\Start")

    While FileExists("E:\Bilder\Steffen\Test\prog\gorem.txt")=0
        sleep(600)
    WEnd
    sleep(800)

;startet kleindiek

$antwort=0
$go=0
    FileCopy("E:\Bilder\Steffen\Test\Start\gobackward.txt", "E:\Bilder\Steffen\Test\prog")

        While FileExists("\Arpc89$KONTROLLE\start.txt")=0
            sleep(600)
        WEnd

        FileDelete("E:\Bilder\Steffen\Test\prog\gobackward.txt")
sleep(600)

        While FileExists("\Arpc89$KONTROLLE\go.txt")=0
            sleep(600)
        WEnd

        sleep(600)

$backward=$backward-1

    FileDelete("E:\Bilder\Steffen\Test\prog\gorem.txt")
    FileDelete("E:\Bilder\Steffen\Test\prog\gobackward.txt")
    FileMove("E:\Bilder\Steffen\Test\Master*.tif" , "E:\Bilder\Steffen\Test\Auswertung")

    sleep(400)

SplashOff()

WEnd

$antwort=0
$go=0

Run("Bildspeichern.exe", "e:\Bilder\Steffen\Test\Start")

While FileExists("E:\Bilder\Steffen\Test\prog\gorem.txt")=0
    sleep(600)
WEnd

FileCopy("E:\Bilder\Steffen\Test\Start\endbild.txt", "E:\Bilder\Steffen\Test\prog")

    While FileExists("\Arpc89$KONTROLLE\start.txt")=0
        sleep(600)
    WEnd

    FileDelete("E:\Bilder\Steffen\Test\prog\endbild.txt")
```

6. Appendix

```
sleep(600)
    While FileExists("\Arpc89\KONTROLLE\go.txt")=0
        sleep(600)
    WEnd
```

```
sleep(800)
```

```
FileDelete("E:\Bilder\Steffen\Test\prog\endbild.txt")
```

```
$gorem=0
Exit
```

Sleeper

```
$sleeper=1
$check=0
$pruefungb=0
$endbild=0
$endmess=0
$startmess=0
$go=0
$gofor=0
$goback=0
$endm=0
```

```
FileDelete("e:\kontrolle\go.txt")
FileDelete("e:\kontrolle\start.txt")
```

```
While $sleeper=1
```

```
    $check=FileExists ("VARLEO1\Bilder2\Steffen\Test\sleeper\sleeper.")
    If $check=1 Then SplashTextOn("Sleeper", "Running", 150, 50, 700, 650, "")
```

```
    If $check=0 Then $sleeper=0
```

```
FileDelete("e:\kontrolle\start.txt")
```

```
    If $startmess=0 Then $startmess=FileExists("\VARLEO1\Bilder2\Steffen\Test\prog\goforward.txt")
```

```
    If $startmess=1 Then FileDelete("e:\kontrolle\go.txt")
```

```
    If $startmess=1 Then Run("gogetforward.exe")
```

```
    $startmess=0
```

```
    While FileExists("\VARLEO1\Bilder2\Steffen\Test\prog\goforward.txt")=1
        sleep(600)
    WEnd
```

```
    sleep(600)
```

```
sleep(600)
```

```
FileDelete("e:\kontrolle\start.txt")
```

```
    If $endmess=0 Then $endmess=FileExists("\VARLEO1\Bilder2\Steffen\Test\prog\gobackward.txt")
```

```
    If $endmess=1 Then FileDelete("e:\kontrolle\go.txt")
```

```
    If $endmess=1 Then Run("gogetback.exe")
```

```
    $endmess=0
```

```
    While FileExists("\VARLEO1\Bilder2\Steffen\Test\prog\gobackward.txt")=1
```

6. Appendix

```
        sleep(600)
        WEnd

        sleep(600)

sleep(600)
$endmess=0

If $endbild=0 Then $endbild=FileExists("\VARLEO1\Bilder2\Steffen\Test\proglendbild.txt")

If $endbild=1 Then FileDelete("e:\kontrolle\go.txt")

If $endbild=1 Then Run("endbild.exe")

$endbild=0

While FileExists("\VARLEO1\Bilder2\Steffen\Test\proglendbild.txt")=1
sleep(600)
WEnd

        sleep(600)

sleep(600)

WEnd

Exit
```

Bildspeichern

```
;bildschiessen
SplashTextOn("Aktiv", "Aufnahme!!!", 400, 200, 100, 100, 16)

WinActivate("SEM -", "")
WinWaitActive("SEM -", "")
Send("!s")
Send("s")
Send("{SPACE}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")
Send("{ENTER}")

WinWaitActive("SEM -", "")

Send("!i")
Send("u")
sleep(1000)

Send("!i")
Send("f")
sleep(10000)

SplashOff()

Send("!f")
Send("e")

WinActivate("Export")
WinWaitActive("Export")
sleep(600)
;directory angeben

Send("{ENTER}")
```


6. Appendix

sleep(600)

WinClose("Export")

FileCopy("E:\Bilder\Steffen\Test\Start\gorem.txt", "E:\Bilder\Steffen\Test\prog")

sleep(400)

Exit

gogetforward

;getdata

FileCopy("E:\Start\start.txt", "E:\kontrolle")

sleep(600)

\$name=0

\$name=FileGetLongName("\VARLEO1\Bilder2\Steffen\Test\Master*.tif")

WinActivate("AcqKnowledge - ", "")

WinWaitActive("AcqKnowledge - ")

send("{F9}")

sleep(400)

send(\$name)

sleep(400)

MouseMove(427, 543)

MouseDown("left")

Sleep(400)

MouseMove(467, 543)

MouseUp("left")

sleep(400)

send("!e")

sleep(400)

send("p")

sleep(400)

send("m")

sleep(400)

WinActivate("Microsoft Excel - ", "")

WinWaitActive("Microsoft Excel - ")

send(\$name)

sleep(400)

send("{RIGHT}")

sleep(400)

send("^v")

sleep(400)

send("{ENTER}")

sleep(400)

send("{DOWN}")

send("{LEFT}")

send("{LEFT}")

sleep(400)

WinActivate("NanoControl 3.1", "")

WinWaitActive("NanoControl 3.1")

MouseMove(303, 220)

MouseClick("left")

6. Appendix

sleep(300)

FileCopy("E:\Start\go.txt", "E:\kontrolle")

sleep(600)

Exit

gogetback

:getdata

FileCopy("E:\Start\start.txt", "E:\kontrolle")

sleep(600)

\$name=0

\$name=FileGetLongName("\\ARLEO1\Bilder2\Steffen\Test\Master*.tif")

WinActivate("AcqKnowledge - ", "")

WinWaitActive("AcqKnowledge - ")

send("{F9}")

sleep(400)

send(\$name)

sleep(400)

MouseMove(427, 543)

MouseDown("left")

Sleep(400)

MouseMove(447, 543)

MouseUp("left")

sleep(400)

send("!e")

sleep(400)

send("p")

sleep(400)

send("m")

sleep(400)

WinActivate("Microsoft Excel - ", "")

WinWaitActive("Microsoft Excel - ")

send(\$name)

sleep(400)

send("{RIGHT}")

sleep(400)

send("^v")

sleep(400)

send("{ENTER}")

sleep(400)

send("{DOWN}")

send("{LEFT}")

send("{LEFT}")

sleep(400)

WinActivate("NanoControl 3.1", "")

WinWaitActive("NanoControl 3.1")

MouseMove(208, 220)

MouseClick("left")

sleep(300)

FileCopy("E:\Start\go.txt", "E:\kontrolle")

sleep(600)

Exit

Endbild

;getdata

FileCopy("E:\Start\start.txt", "E:\kontrolle")

sleep(600)

\$name=0

\$name=FileGetLongName("\VARLEO1\Bilder2\Steffen\Test\Master*.tif")

WinActivate("AcqKnowledge - ", "")

WinWaitActive("AcqKnowledge - ")

send("{F9}")

sleep(400)

send(\$name)

sleep(400)

MouseMove(427, 543)

MouseDown("left")

Sleep(400)

MouseMove(447, 543)

MouseUp("left")

sleep(400)

send("le")

sleep(400)

send("p")

sleep(400)

send("m")

sleep(400)

WinActivate("Microsoft Excel - ", "")

WinWaitActive("Microsoft Excel - ")

send(\$name)

sleep(400)

send("{RIGHT}")

sleep(400)

send("^v")

sleep(400)

send("{ENTER}")

sleep(400)

send("{DOWN}")

send("{LEFT}")

send("{LEFT}")

sleep(400)

FileCopy("E:\Start\go.txt", "E:\kontrolle")

sleep(600)

Exit

ii) Deflection measurement

- Store all micrographs in the folder “auswertung” on drive “C:\”
- Run: Auswertung_Leo_Bilder

Auswertung_Leo_Bilder

```
$loop=1
$loopnum=1
$frage=1

send("#")
WinWaitActive("Ausführen")
send("C:\Programme\Corel\Graphics10\Programs\coreldrw.exe")
send("{enter}")
sleep(1000)
WinActivate("CoreIDRAW 10", "")
WinWaitActive("CoreIDRAW 10")
send("^n")

send("#")
WinActivate("Ausführen", "")
WinWaitActive("Ausführen")
send("C:\Programme\Microsoft Office\Office10\excel.exe")
send("{enter}")
WinActivate("Microsoft Excel", "")
WinWaitActive("Microsoft Excel")

$speichername = InputBox("Question", "Speichern unter?")
$loopnum0 = InputBox("Question", "Wie viele Bilder?", "1")
$frage=MsgBox (1, "Frage", "Jedesmal fragen?")

If $speichername=1 Then exit

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
;Send("^n")
Send("!d")
Send("u")
WinWaitActive("Speichern unter")
send($speichername)
send("{enter}")
WinWaitActive("Microsoft Excel -")
send($speichername)
send("{enter}")
send("{enter}")
send("Laenge des µm-Balkens [mm]")
Send("{DOWN}")
send("{enter}")
send("{enter}")
send("Bildname")
Send("{RIGHT}")
send("Position x [mm]")
Send("{RIGHT}")
send("Position y [mm]")
Send("{RIGHT}")
send("Auslenkung [µm]")
Send("{LEFT}")
Send("{LEFT}")
Send("{UP}")
Send("{UP}")
Send("{UP}")

WinActivate("C:\auswertung", "")
WinWaitActive("C:\auswertung")
Send("^c")
WinWaitActive("C:\auswertung")
```

6. Appendix

```
WinActivate("CoreIDRAW 10 -", "")
WinWaitActive("CoreIDRAW 10 -")
Send("^v")

MsgBox (0, "Frage", "Bitte µm-Balken einrahmen")
$balken = InputBox("Question", "µm-Balkenlänge in µm?", "1")

WinActivate("CoreIDRAW 10 -", "")
WinWaitActive("CoreIDRAW 10 -")
BlockInput(1)
MouseMove(158,92, 1)
MouseClick("left")
Send("{LEFT}")
Send("{LEFT}")
Send("+{HOME}")
Send("^c")
BlockInput(0)

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
Send("^v")
Send("{RIGHT}")
send("µm-Balkenlänge")
Send("{RIGHT}")
Send($balken)
Send("{DOWN}")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
Send("{DOWN}")
Send("{DOWN}")
Send("{DOWN}")

WinActivate("CoreIDRAW 10 -", "")
WinWaitActive("CoreIDRAW 10 -")
Send("{DEL}")
Send("{TAB}")
Send("{DEL}")

While $loop=1

If $loopnum=$loopnum0 Then $loop=2
$loopnum=$loopnum+1

WinActivate("C:\auswertung", "")
WinWaitActive("C:\auswertung")
Send("{F2}")
WinWaitActive("C:\auswertung")
Send("^c")
WinWaitActive("C:\auswertung")
Send("{ENTER}")
WinWaitActive("C:\auswertung")

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
BlockInput(1)
Send("^v")
WinWaitActive("Microsoft Excel -")
Send("{RIGHT}")
WinWaitActive("Microsoft Excel -")
BlockInput(0)

WinActivate("C:\auswertung", "")
WinWaitActive("C:\auswertung")
Send("^c")
WinWaitActive("C:\auswertung")
```

6. Appendix

```
WinActivate("CorelDRAW 10 -", "")
WinWaitActive("CorelDRAW 10 -")
Send("^v")
Send("{PGDN}")
Send("{TAB}")

MsgBox (0, "Frage", "Kastenziehen!!!!")
Sleep(500)

WinActivate("CorelDRAW 10 -", "")
WinWaitActive("CorelDRAW 10 -")
BlockInput(1)
MouseMove(87, 95, 1)
MouseClick("left")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
Send("{HOME}")
Send("^c")
BlockInput(0)

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
Send("^v")
Send("{RIGHT}")

WinActivate("CorelDRAW 10 -", "")
WinWaitActive("CorelDRAW 10 -")
BlockInput(1)
MouseMove(87, 108, 1)
MouseClick("left")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
Send("{HOME}")
Send("^c")
BlockInput(0)

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
BlockInput(1)
Send("^v")
Send("{RIGHT}")
Send("=($C$7-C" & 5 + $loopnum & ")/$B$3*$D$3")
Send("{DOWN}")
Send("{LEFT}")
Send("{LEFT}")
Send("{LEFT}")
BlockInput(0)

WinActivate("CorelDRAW 10 -", "")
WinWaitActive("CorelDRAW 10 -")
Send("{TAB}")
Send("{DEL}")

If $frage=1 Then $loop=MsgBox (1, "Frage", "naechstes Bild??")

If $loop=1 Then WinActivate("C:\auswertung", "")
If $loop=1 Then WinWaitActive("C:\auswertung")
If $loop=1 Then Send("{DOWN}")

WEnd

WinActivate("Microsoft Excel -", "")
WinWaitActive("Microsoft Excel -")
send("^s")

Winkill("CorelDRAW 10")
```

exit

iii) Tensile Testing

Fib_Forward

- Prepare the sample
- Open Acqknowledge run the data-acquisition
- Open Kleindiek Nanocontrol
- Open an Excel file

```
;getdata
```

```
WinActivate("NanoControl 3.1", "")  
WinWaitActive("NanoControl 3.1")
```

```
MouseMove(303, 220)  
MouseClick("left")
```

```
sleep(2000)  
WinActivate("AcqKnowledge - ", "")  
WinWaitActive("AcqKnowledge - ")
```

```
sleep(400)
```

```
MouseMove(427, 543)  
MouseDown("left")  
Sleep(400)  
MouseMove(467, 543)  
MouseUp("left")  
sleep(400)
```

```
send("e")  
sleep(400)  
send("p")  
sleep(400)  
send("m")  
sleep(400)
```

```
WinActivate("Microsoft Excel - ", "")  
WinWaitActive("Microsoft Excel - ")
```

```
sleep(400)
```

```
send("^v")  
sleep(400)  
send("{ENTER}")  
sleep(400)  
send("{DOWN}")  
send("{LEFT}")
```

```
sleep(400)
```

```
WinActivate("AcqKnowledge - ", "")  
WinWaitActive("AcqKnowledge - ")
```

```
send("{F9}")
```

```
Exit
```

Fib_Back

- Prepare the sample
- Open Acqknowledge run the data-acquisition
- Open Kleindiek Nanocontrol
- Open an Excel file

```
:getdata
```

```
WinActivate("NanoControl 3.1", "")  
WinWaitActive("NanoControl 3.1")
```

```
    MouseMove(208, 220)  
    MouseClick("left")
```

```
    sleep(2000)
```

```
WinActivate("AcqKnowledge - ", "")  
WinWaitActive("AcqKnowledge - ")
```

```
    sleep(400)
```

```
    MouseMove(427, 543)  
    MouseDown("left")  
    Sleep(400)  
    MouseMove(467, 543)  
    MouseUp("left")  
    sleep(400)
```

```
    send("!e")  
    sleep(400)  
    send("p")  
    sleep(400)  
    send("m")  
    sleep(400)
```

```
WinActivate("Microsoft Excel - ", "")  
WinWaitActive("Microsoft Excel - ")
```

```
    send("^v")  
    sleep(400)  
    send("{ENTER}")  
    sleep(400)  
    send("{DOWN}")  
    send("{LEFT}")
```

```
    sleep(400)
```

```
WinActivate("AcqKnowledge - ", "")  
WinWaitActive("AcqKnowledge - ")
```

```
sleep(400)  
send("{F9}")
```

```
sleep(600)
```

```
Exit
```


iv) Extraction of the grey values

- Store all micrographs in a folder “auswertung” on drive “C:\”
- Select the first file containing the first micrograph
- Open ImageJ
- Create a macro, which contains the coordinates of the line along which the grey values should be extracted and the command “Plot Profile”
- Open a Excel woorksheed and select the column A row 10
- Run: Grauwerte_Excel

Grauwerte_Excel:

```
Opt("MouseCoordMode", 0)

$speichername=0
$loop=1
$loopnum=1
$frage=1

$loopnum0 = InputBox("Question", "Wie viele Bilder?", "1")
$frage=MsgBox (1, "Frage", "Jedesmal fragen?")

If $speichername=1 Then exit

While $loop=1

If $loopnum=$loopnum0 Then $loop=2
$loopnum=$loopnum+1

Sleep(200)

WinActivate("auswertung", "")
WinWaitActive("auswertung")
Send("{F2}")
WinWaitActive("auswertung")
Send("^c")
WinWaitActive("auswertung")
Send("{ENTER}")
WinWaitActive("auswertung")

WinActivate("Microsoft Excel", "")
WinWaitActive("Microsoft Excel")
Send("^v")
Send("{Down}")
Send("{Down}")
Send("Length [Pixel]")
Send("{RIGHT}")
Send("Gray-Scale")
Send("{LEFT}")
Send("{Down}")
Send("{Down}")

WinActivate("ImageJ", "")
WinWaitActive("ImageJ")
Send("^o")
WinActivate("Open", "")
WinWaitActive("Open")

Sleep(600)
Send("^v")
Sleep(400)
Send("{ENTER}")
Sleep(800)
```

```
;WinActivate("ClipGet()", "")
;WinWaitActive("ClipGet()")

Sleep(400)
WinActivate("Macro.txt", "")
WinWaitActive("Macro.txt")
Sleep(400)
Send("{ENTER}")
Send("^r")
Sleep(800)

WinActivate("Plot", "")
Sleep(400)
WinClose(ClipGet(), "")
Sleep(400)

WinActivate("Plot", "")
Sleep(400)

MouseMove(141, 315, 1)
Sleep(400)
MouseClick("left")

Sleep(400)

WinActivate("Microsoft Excel", "")
WinWaitActive("Microsoft Excel")
Send("^v")

Send("{RIGHT}")
Send("{RIGHT}")
Send("{RIGHT}")
Send("{UP}")
Send("{UP}")
Send("{UP}")
Send("{UP}")
Send("{UP}")
Sleep(400)

WinClose("Plot", "")
;WinClose(ClipGet(), "")

If $frage=1 Then $loop=MsgBox (1, "Frage", "naechstes Bild??")

If $loop=1 Then WinActivate("auswertung", "")
If $loop=1 Then WinWaitActive("auswertung")
If $loop=1 Then Send("{DOWN}")

WEnd

Exit
```

v) Fitting of the grey values

- Open Origin 7
- Open the Excel file containing the grey values, select the first name of the first set
- Load the first set of the grey values in Origin
- Fit one peak with a Gaussian-fit in the advanced fitting tools

```
Opt("MouseCoordMode", 0)

$speichername=0
$loop=1
$loopnum0=1
$frage=1
```

6. Appendix

```
$loopnum0 = InputBox("Question", "Wie viele Bilder?", "1")
```

```
While $loopnum0 >=1
```

```
WinActivate("Microsoft Excel", "")  
WinWaitActive("Microsoft Excel", "")  
Send("{DOWN}")  
Send("{DOWN}")  
Send("{DOWN}")  
Send("{DOWN}")
```

```
Send("+{RIGHT}")  
;Send("+{RIGHT}")
```

```
Send("+{END}")  
Send("+{DOWN}")
```

```
Send("^c")
```

```
Winactivate("Origin", "")  
WinWaitActive("Origin", "")  
Send("f")  
Send("1")  
Send("^v")
```

```
WinActivate("Nichtlinear", "")  
WinWaitActive("Nichtlinear", "")  
MouseMove(210, 440, 1)  
MouseClick("left")  
Sleep(500)  
MouseClick("left")  
Sleep(500)  
MouseClick("left")  
Sleep(500)  
MouseClick("left")  
Sleep(500)
```

```
Send("{TAB}")  
Send("{TAB}")
```

```
Send("^c")
```

```
WinActivate("Microsoft Excel", "")  
WinWaitActive("Microsoft Excel", "")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")  
Send("{UP}")
```

```
Send("y0")  
Send("{RIGHT}")  
Send("^v")  
Send("{LEFT}")  
Send("{DOWN}")
```

```
WinActivate("Nichtlinear", "")  
WinWaitActive("Nichtlinear", "")
```

```
Send("{TAB}")  
Send("^c")
```

```
WinActivate("Microsoft Excel", "")
```

6. Appendix

```
WinWaitActive("Microsoft Excel", "")
```

```
Send("xc")  
Send("{RIGHT}")  
Send("^v")  
Send("{LEFT}")  
Send("{DOWN}")
```

```
WinActivate("Nichtlinear", "")  
WinWaitActive("Nichtlinear", "")
```

```
Send("{TAB}")  
Send("^c")
```

```
WinActivate("Microsoft Excel", "")  
WinWaitActive("Microsoft Excel", "")
```

```
Send("w")  
Send("{RIGHT}")  
Send("^v")  
Send("{LEFT}")  
Send("{DOWN}")
```

```
WinActivate("Nichtlinear", "")  
WinWaitActive("Nichtlinear", "")
```

```
Send("{TAB}")  
Send("^c")
```

```
WinActivate("Microsoft Excel", "")  
WinWaitActive("Microsoft Excel", "")
```

```
Send("A")  
Send("{RIGHT}")  
Send("^v")  
Send("{DOWN}")  
Send("{DOWN}")  
Send("{RIGHT}")  
Send("{RIGHT}")
```

```
$loopnum0=$loopnum0-1
```

```
WEnd
```

```
Exit
```